Characterization of Pedot:tosylateMicroelectrodes for Transmitter Detection

Larsen, Simon Tylsgaard; Vreeland, Richard F ; Heien, Michael L; Taboryski, Rafael J.

Publication date:
2012

DTU Nanotech
Department of Micro- and Nanotechnology

Characterization of Pedot:tosylate Microelectrodes for Transmitter Detection

Simon T Larsen[1], Richard F Vreeland[2], Michael L Heien[2], Rafael J Taboryski[1]

1) Technical University of Denmark, 2) University of Arizona

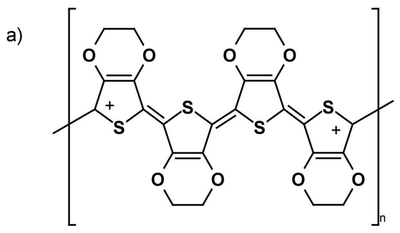

Figure 1: The chemical structure of a) positively charged Pedot and b) negatively charged tosylate counter ion

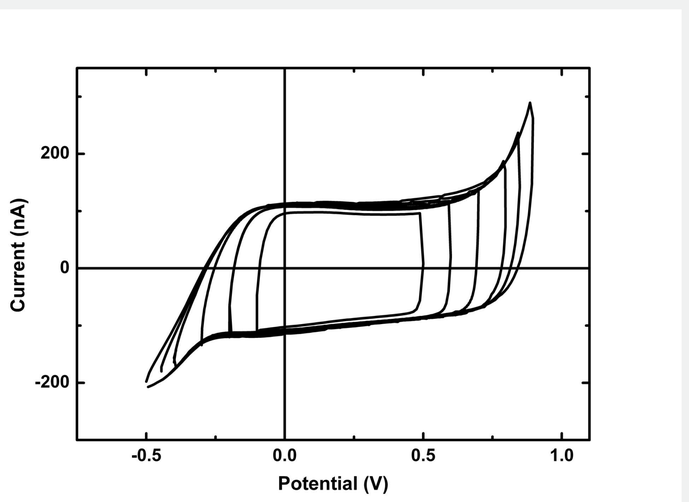

Figure 2: Cyclic voltammograms showing the background current towards an Ag/AgCl reference electrode for a Pedot:tosylate electrode in PBS buffer. Electrode area 12 µm X 6000 µm. Scan rate 100 mV/s.

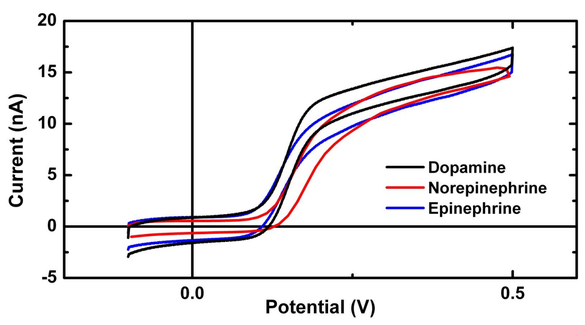

Figure 3: Cyclic voltammograms showing the oxidation of dopamine (DA), norepinephrine (NE) and epinephrine (EPI) at a 12 µm X 6000 µm Pedot:tosylate electrode. Scan rate 1 mV/s. Concentration 20 µM.

Electrochemical detection of neurotransmitters and other oxidizing species is a widely used technique in applications such as high-performance liquid chromatography, capillary electrophoresis, and constant potential amperometry at living cells. For integration in miniaturized devices, microfabricated electrodes have been tested for use in these applications in a range of different materials. Here, we investigate the potential of the conducting polymer Poly(3,4-ethylenedioxythiophene):tosylate (Pedot:tosylate) for neurochemical detection. Band electrodes were fabricated with widths down to 3 µm using UV lithographic methods and a range of transmitters were shown to oxidize readily on the electrodes. Electrochemical and physical properties of the electrodes are reported, including potential limits, resistance, capacitance, kinetic rate constants and half wave potentials. Finally, we use constant potential amperometry and Pedot:tosylate electrodes to measure the release of neurotransmitters from a group of PC 12 cells.

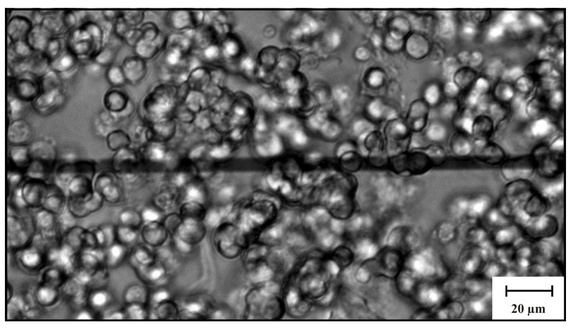

Figure 2: PC 12 cells sedimented on a 7 µm wide Pedot:tosylate electrode.

Table 1 Physical properties of PEDOT:tosylate film electrodes (thickness = 190 nm). Error is the standard deviation (n = 10)

Sheet resistance	113 ± 7 Ω
Capacitance per unit area	1700 ± 100 µF cm^{-2}
Potential limits (*vs.* Ag/AgCl)	−200 mV, 700 mV

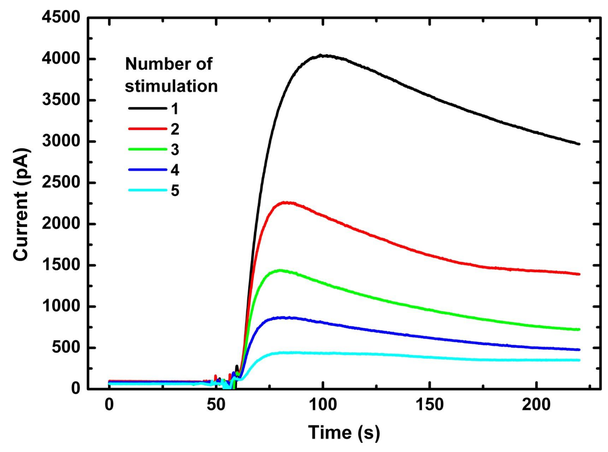

Figure 5: Amperometric responses resulting from neurotransmitter release from a group of PC 12 cells at a Pedot:tosylate electrode. The cells were alternately exposed to a K^+-rich buffer for 3 minutes and a low K^+ buffer for 4 minutes. The highest response resulted from the first stimulation by a K^+-rich buffer. Subsequent stimulations resulted in decreasing current responses.

Table 2 Heterogeneous electron transfer rate constants for selected molecules[a]

	DOPAC	HVA	DA	NE	E	L-DOPA	5-HIAA	5-HT	Hist	Fc-COOH
k_{avg}	3.1	1.3	3.1	2.3	1.5	3.3	1.3	2.3	n/a	4.9
±	0.8	0.2	0.6	0.4	0.7	0.4	0.7	0.9	—	0.6
E½	141	403	149	164	144	163	291	327	—	213
±	4	18	7	4	4	2	7	4	—	3

Simon Tylsgaard Larsen
PhD Student
sitl@nanotech.dtu.dk

DTU Nanotech
Department of Micro- and Nanotechnology
Technical University of Denmark
www.nanotech.dtu.dk